

soil in the case of all the plants except the lupins, and for these from a special sandy soil from a field in which lupins were growing. No. 4 garden soil, or, for the lupins, the special lupin soil. With regard to the peas and vetches of the pots not seeded with soil extract, the growth was extremely limited, and the colour of the leaves pale green; in the second and third pots of the two series there was luxuriant growth, the plants being taller even than those grown in garden soil. On the other hand, the garden soil plants were more vigorous and produced flower and seed. An examination of the roots of the plants showed an entire absence of nodule formation on those of the pots where no soil extract was given, whilst on the roots of the other plants there was, coincidentally with the increased growth, an abundance of nodules. As in the experiments of 1888, the amount of nodules on the roots of the plants grown in garden soil was less than in the sand treated with soil extract.

Still more striking were the results obtained with yellow lupins. Whilst the plants of pot 1 (without soil extract) barely appeared above the rim of the pot, those of pots 2 and 3 (with soil extract) were large branched plants, the largest being 2 feet high—larger even than those grown in the lupin soil. Moreover, unlike the peas and vetches, the yellow lupins grown in sand seeded with soil organisms, flowered and seeded freely. The superiority of these plants over those grown in the lupin sandy soil may be due to the fact that the lupin soil was much less porous than the sand, especially when watered, and perhaps on this account less adapted for favourable growth. The roots of the plants without soil extract seeding were of very limited development and quite free from nodules. In pots 2 and 3, with soil extract seeding, the root development was very great, and the roots showed several large swellings; the ends of the roots were thickly covered with root-hairs, probably indicating an effort to acquire water and mineral nutriment in quantity commensurate with the large amount of nitrogen fixed, and so rendered available to the plant. In the garden soil the root development and nodule formation were much less.

The blue lupins again failed, with the exception of one plant in one pot. The red clover and lucerne are left for further growth. In pot 1 (unseeded) of the lucerne the plants do not appear to have grown at all since a few weeks after the seeds were sown, and for a long time there seemed to be no increased growth in pots 2 and 3, which were seeded with garden soil extract. Pot 2 had, therefore, a fresh quantity of soil extract—this time from a soil where lucerne was growing—added; this also seemed for some time to have no effect, but subsequently there was some increased depth of colour and some increased growth. Pot 3 was watered with a dilute solution of calcium nitrate, which soon produced a very marked and beneficial effect. With regard to the red clover, the results are, as yet, uncertain; both in the pots to which soil extract was added, and in that which had no soil extract, there is much more growth than is believed can be accounted for by nitrogen in the seed sown. The glass house in which the experiments are made stands in the middle of allotment gardens where vegetables of all kinds are grown, and this fact, viewed in the light of Hellriegel and Wilfarth's more recent results, already referred to—according to which the best results with clover are obtained by seeding with organisms from a root-crop soil—points to a possible acquisition of organisms from the air as the most probable explanation.

Attention is drawn to the widely different external appearance of the tubercles of the different plants. In the case of peas, they occurred generally as agglomerations; on the roots of vetches the nodules were generally single. Lupins seem to have two kinds of tubercular development, the most prevalent being "swellings" which entirely encase the thick roots; the "nodules" are generally small, and are distributed on the root-fibres. The lucerne nodules are, again, quite different in form from any of those already mentioned, being long, and generally divided or branched.

Returning to the main object of the investigation, the results confirm those of Hellriegel and Wilfarth, in showing the fixation of free nitrogen under the influence of microbe-seeding of the soil, and the resulting nodule formation on the roots in the case of the leguminous plant.

It appears that, concurrently with the experiments made at Rothamsted, M. Bréal, of the Muséum d'Histoire Naturelle of Paris, has made various experiments instigated by the results of Hellriegel and Wilfarth, and his results also confirm those of Hellriegel.

Hellriegel agrees with the authors that the *Leguminosæ* utilize

soil nitrogen. He considers that the soil would be drawn upon first, and that this source is supplemented by the elementary nitrogen of the air, brought into combination by means of the organisms; he also considers that there would be more or less fixation even with a soil rich in nitrogen. On the other hand, Vines found the formation of tubercles, and presumably also the fixation of free nitrogen, is much reduced, or even stopped altogether, by the application of much nitrate to the soil; and the Rothamsted experiments indicate, that with a rich garden soil there are far fewer nodules formed, than with a sand containing but little nitrogen, and seeded with soil organisms. If subsequent experiments should show this to be the case, the amount of nitrogen of a crop, derived from the air, and the amount derived from a soil, would vary very much according to circumstances; fixation would take place most freely in the case of a sandy, or poor and porous soil, and less in a richer soil.

Upon the whole, it is considered that the evidence at command points to the conclusion that, in the case of most, if not all our leguminous crops, more or less of their nitrogen will be due to fixation under the conditions supposed.

Regarding the mode in which the organisms, which, in symbiosis with the higher plants, bring about the fixation, although Marshall Ward, Prazmowski, and Beyerinck have already contributed interesting results as to the mode of life of these bodies, much has yet to be learnt on the subject before an adequate explanation of the phenomena involved can be given. The authors suggest the following alternatives:—“(1) That, somehow or other, the plant itself is enabled, under the conditions of symbiotic life, to fix free nitrogen of the atmosphere by its leaves—a supposition in favour of which there seems to be no evidence whatever. (2) That the parasite utilizes and fixes free nitrogen, and that the nitrogenous compounds formed are taken up by the host. On such a supposition, the actually ascertained large gain of nitrogen by the leguminous plant growing in a nitrogen-free, but properly infected soil, becomes intelligible.”

In their former paper (*loc. cit.*) the authors had stated that all the evidence that had been acquired in lines of inquiry previously followed had failed to solve conclusively the question of the sources of the whole of the nitrogen of the *Leguminosæ*, and that hence it should not excite surprise that new light should come from a new line of inquiry.

“The question suggests itself, whether such, or allied agency, comes into play in the nitrogen assimilation of leguminous plants generally, or that of other than the agricultural representatives of the non-leguminous families to which we owe such plants, or of those of the numerous and varied other families of the vegetable kingdom.

“It is true that the families which contribute staple agricultural plants are but few, and that the agricultural representatives of those families are also comparatively few. The families so contributing are, however, among the most important and widely distributed in the vegetable kingdom; as also are some of the plants they contribute. As prominent examples may be mentioned the *Gramineæ*, affording the cereal grains, a large proportion of the mixed herbage of grass-land, and other products; also the *Leguminosæ*, yielding pulse-crops, many useful herbage plants, and numerous other products. As we have said, there does not seem to be an unsolved problem as to the sources of the nitrogen of other of our agricultural plants than those of the leguminous family. Obviously, however, it would be unsafe to generalize in regard to individual families as a whole, from results relating to a limited number of examples supplied by their agricultural representatives alone. Still, there is nothing in the evidence at present at command to point to the supposition that there is any fundamental difference in the source of the nitrogen of different members of the same family, such as is clearly indicated between the representatives of the leguminous, and of the other families, supplying staple agricultural products. On the other hand, existing evidence does not afford any means of judging whether or not similar, or allied agencies to those now under consideration, or even quite different ones, may come into play in the nitrogen assimilation of other families which contribute such a vast variety of vegetation to the earth's surface.”

N. H. J. M.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—At the meeting of the Philosophical Society, on Monday, May 12, at 4.30 p.m., the following papers are promised:—

Mr. Langley, effect of nicotin on the nervous system of the fresh-water crayfish.

Mr. Shipley, on a new species of Phymosoma, with some account of the geographical distribution of the genus.

Mr. Adami, on the action of the papillary muscles of the heart.

Mr. Harmer, exhibition of specimens of a Land-Planarian (*Rhynchodemus terrestris*, O. F. Müller) found in Cambridge.

SCIENTIFIC SERIALS.

THE *American Meteorological Journal* for March contains the conclusion of M. Faye's articles on the theory of storms, based on Redfield's laws. The author maintains that cyclones are descending whirls with a vertical axis, that they originate in the upper currents of the atmosphere, and follow the course of these currents. He considers it very desirable that two different modes of drawing charts should be adopted, to distinguish between cyclones and statical depressions to which, in his opinion, the laws of storms do not in any way apply.—Prof. H. A. Hazen contributes an article on the spectre of the Brocken, and gives a summary of various explanations of the phenomenon. He gives the results of his observations upon a similar shadow seen upon Mount Washington. This number also contains an extract from a paper by Dr. Schenck on the climatic treatment of pulmonary consumption; the advantages of New Mexico, especially, are pointed out.

In the number of the *Journal* for April, M. Faye commences a series of articles on trombes and tornadoes; he deals principally in this number with the theories of various writers and with descriptions of the phenomenon.—Mr. A. H. Dutton analyses the laws laid down by Padre Viñes relative to the normal points of recurvature of West India hurricanes. The result of his inquiry is that less than 14 per cent. of the tropical storms obeyed the laws.—Mr. A. L. Rotch summarizes the proceedings of the International Hydrological Congress held at Paris in October last. The next Congress is to be held in Rome in 1892.

Department of Agriculture, Bulletin No. 4, July 1889 (by authority, Government Printing Office, Melbourne)—This Report embodies the results of State-aided scientific effort which is intended to benefit agriculture, as we sincerely trust it will. The contents are miscellaneous, although all have direct bearing on the theory and practice of agriculture. Reports on horse-breeding, the needs of plants, irrigation, liquorice, yields of milk, vineyards, fruit-culture, Danish dairying, &c., yield a varied diet for the omnivorous reader, and will be of special service to Australian cultivators. We plead guilty to a feeling in connection with the perusal of such *Bulletins* as this, that the work is official, and lacks spontaneity. There is, notwithstanding, much that is valuable. Take, for example, the raisin industry (p. 91). Here we find described the conditions for successful growth, varieties, cultivation, and drying. What can be more useful to a colonist up country than to possess trustworthy information in detail on such a subject? If he is engaged in the wider pursuits of horse or cattle ranching, he will find subject-matter—addresses of breeders, names of sires, and other information of solid value. The *Bulletin* will also be of interest to the increasing class of owners of land in Australia who reside in England, as well as to young men who are thinking of making Australia their home. Anyone writing for this class of information should secure the previous numbers and also the future issues, and these he would probably be able to obtain free of charge by application at the offices of the Agricultural Department at Melbourne, or in London, at the Australian Colonial Offices in Victoria Street.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, March 27.—“Measurements of the Amount of Oil necessary in order to check the Motions of Camphor upon Water.” By Lord Rayleigh, Sec. R.S.

The motion upon the surface of water of small camphor scrapings, a phenomenon which had puzzled several generations of inquirers, was satisfactorily explained by Van der Mensbrugghe (*Mémoires Couronnés* (4to) of the Belgian Academy, vol. xxxiv., 1869), as due to the diminished surface-tension of water impregnated with that body. In order that the rotations may be lively, it is imperative, as was well shown by Mr.

Tomlinson, that the utmost cleanliness be observed. It is a good plan to submit the internal surface of the vessel to a preliminary treatment with strong sulphuric acid. A touch of the finger is usually sufficient to arrest the movements by communicating to the surface of the water a film of grease. When the surface-tension is thus lowered, the differences due to varying degrees of dissolved camphor are no longer sufficient to produce the effect.

It is evident at once that the quantity of grease required is excessively small, so small that under the ordinary conditions of experiment it would seem likely to elude our methods of measurement. In view, however, of the great interest which attaches to the determination of molecular magnitudes, the matter seemed well worthy of investigation; and I have found that by sufficiently increasing the water surface the quantities of grease required may be brought easily within the scope of a sensitive balance.

In the present experiments the only grease tried is olive oil. It is desirable that the material which is to be spread out into so thin a film should be insoluble, involatile, and not readily oxidized, requirements which greatly limit the choice.

Passing over some preliminary trials, I will now describe the procedure by which the density of the oil film necessary for the purpose was determined. The water was contained in a sponge-bath of extra size, and was supplied to a small depth by means of an india-rubber pipe in connection with the tap. The diameter of the circular surface thus obtained was 84 cm. (33"). A short length of fine platinum wire, conveniently shaped, held the oil. After each operation it was cleaned by heating to redness, and counterpoised in the balance. A small quantity of oil was then communicated, and determined by the difference of readings. Two releasements of the beam were tried in each condition of the wire, and the deduced weights of oil appeared usually to be accurate to $\frac{1}{100}$ milligram at least. When all is ready, camphor scrapings are deposited upon the water at two or three places widely removed from one another, and enter at once into vigorous movement. At this stage the oiled extremity of the wire is brought cautiously down so as to touch the water. The oil film advances rapidly across the surface, pushing before it any dust or camphor fragments which it may encounter. The surface of the liquid is then brought into contact with all those parts of the wire upon which oil may be present, so as to ensure the thorough removal of the latter. In two or three cases it was verified by trial that the residual oil was incompetent to stop camphor motions upon a surface including only a few square inches.

The manner in which the results are exhibited will be best explained by giving the details of the calculation for a single case, e.g. the second of December 17. Here 0.81 milligram of oil was found to be nearly enough to stop the movements. The volume of oil in cubic centimetres is deduced by dividing 0.00081 by the sp. gr., viz. 0.9. The surface over which this volume of oil is spread is

$$\frac{1}{4}\pi \times 84^2 \text{ square centimetres;}$$

so that the thickness of the oil film, calculated as if its density were the same as in more normal states of aggregation, is

$$\frac{0.00081}{0.9 \times \frac{1}{4}\pi \times 84^2} = \frac{1.63}{10^7} \text{ cm.,}$$

or 1.63 micro-millimetres. Other results, obtained as will be seen at considerable intervals of time, are collected in the table.

A Sample of Oil, somewhat decolorized by exposure.

Date.	Weight of oil.	Calculated thickness of film.	Effect upon camphor fragments.
	Mg.		
December 17 ...	0.40	0.81	No distinct effect.
January 11 ...	0.52	1.06	Barely perceptible.
„ 14 ...	0.65	1.32	Not quite enough.
December 20 ...	0.78	1.58	Nearly enough.
January 11 ...	0.78	1.58	Just enough.
December 17 ...	0.81	1.63	Just about enough.
„ 18 ...	0.83	1.68	Nearly enough.
January 22 ...	0.84	1.70	About enough.
December 18 ...	0.95	1.92	Just enough.
„ 17 ...	0.99	2.00	All movements very nearly stopped.
„ 20 ...	1.31	2.65	Fully enough.